Structure and Properties of Bone as a Polymer-Mineral Composite Material

STONY BROOK
STATE UNIVERSITY OF NEW YORK

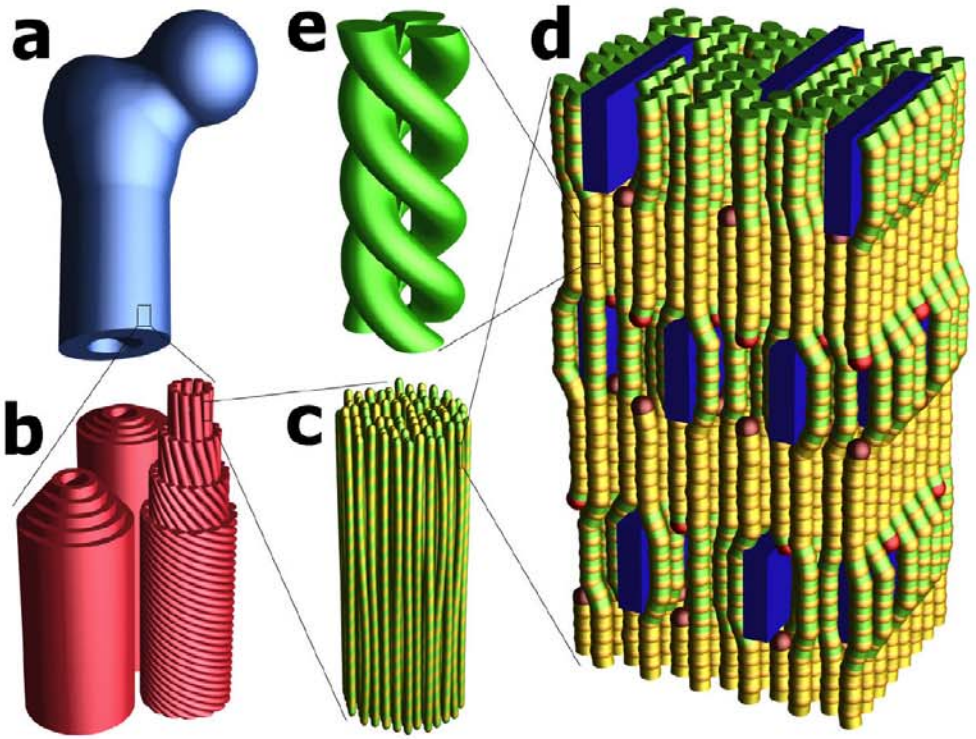
H.W. Zhou, J.L. Chen, C. Burger, B.S. Hsiao, B. Chu*
State University of New York at Stony Brook

DMR-9984102

Bone can be considered a mineral-filled polymer composite, consisting of collagen fibers and embedded calcium hydroxy-apatite crystals, with quite unique properties, e.g. mechanical toughness.

Bone shows a hierarchy of structural organization, extending over several orders of magnitude in length scale as schematically shown in the figure.

While the structure and property relationships of bone have been studied for over a century, today's advanced experimental and analytical tools provide valuable new insights into this fundamentally important system.



Schematic representation of the hierarchical structures in bone: (a) Macroscopic bone. (b) Osteons (~ 100 μm) with circular arrangements of differently oriented collagen fibers. (c) Collagen fiber (~ 5 μm lateral) consisting of bundles of collagen fibrils (~ 500 nm lat.). (d) Striped collagen fibril (period ~ 68 nm longitudinal) consisting of a staggered arrangement of collagen molecules (~ 1.5 nm lat.) with embedded mineral crystals (~ 2–20 nm lat., 30 nm long.). (e) Collagen molecule triple helix.

Structure and Properties of Bone as a Polymer-Mineral Composite Material

STONY BROOK
STATE UNIVERSITY OF NEW YORK

Project Goals and Impacts

- Structural investigation of bone by scattering techniques, small-angle x-ray scattering (SAXS) and wide-angle x-ray scattering (WAXS), using state-of-the-art technology like 2^{nd} and 3^{rd} generation synchrotron sources, advanced beamlines and highly dynamic 2D detectors.

- Detailed study of the mineralization process by re-mineralizing de-mineralized bone samples under controlled conditions and external stimuli like electric fields. Comparison of the mineralization behavior of de-mineralized bone with other types of collagen fibers including native non-bone fibers and artificially electro-spun fibers.

- Advances in data quality and data analysis: Accurate investigation of the development of lateral and longitudinal order and domain sizes as well as effects of preferred orientation, as a function of the degree of mineralization.

- Medical impact: Improvement in bone disease treatments. Collaboration with M. Glimcher, Harvard Medical School.